WASHING MACHINE

【0001】

BACKGROUND OF THE INVENTION

The present invention relates to an electric motor which uses a permanent magnet as a field magnet, particularly to an electric motor for driving a washing machine and a control method thereof, and relates to an electric motor and a control method thereof in which positions of the magnetic pole centers of said first field magnet and said second field magnet can be changed, and the amount of the effective magnetic flux can be changed according to the number of revolution.

【0002】

In a permanent magnet field type electric motor of the prior art, an induced electromotive force E is determined by a constant magnetic flux Φ generated by a permanent magnet arranged in a rotor and a rotating angular speed ω of the motor. That is, when the rotating angular speed ω (rotating speed) of the motor is increased, the induced electromotive force is proportionally increased.

【0003】

Accordingly, high torque can be obtained in a low speed range, but operation in a high-speed range is difficult because the variable range of rotating speed is narrow. Therefore, it

may be considered that the high-speed operation range is widened using a field weakening control technology.

【0004】

Moreover, the torque of the electric motor is transmitted by the belt and the gear through pulley so that the electric motor of the washing machine may secure a fixed power output in a wide speed range. However, there is a direct drive method of transmitting the torque of the electric motor directly to the body of revolution and the spin-drying drum such as pulsators recently.

【0005】

There is a big problem with large noises of the sliding and the shock sound etc. of the belt and the gear when the torque of an electric motor is transmitted by the belt and the gear through pulley in the conventional washing machine.

【0006】

Moreover, expanding a high-speed operating range by using said field-weaking control technology has the limit in the direct drive method of transmitting the torque of the electric motor directly to the body of revolution (for instance, pulsator etc.) and spin-drying drums due to the heat generation by the field weakening electric current and the decrease in efficiency, etc. Because said direct drive method does not have the speed reducer, the electric motor which can cover a wide-ranging speed region

of the washing and the rinsing operation by low-speed high torque and the spin-drying operation by high-speed large power becomes large-scale.

【0007】

SUMMARY OF THE INVENTION

In the present invention, the following washing machine is used. The washing machine comprises a washing spin-drying drum pivotted freely around a rotation axis in the outside tank, a body of revolution pivotted freely around a rotation axis whose center is the same as one of said rotation axis at the bottom of said washing spin-drying drum, a change-over mechanism for connecting or releasing the rotation axis of said washing spin-drying drum to the rotation axis of the body of revolution, and an electric motor, whereby washing or rinsing operation is carried out by rotating forward or reversely the body of revolution to stir the inside of said washing spin-drying drum, and then spin-drying operation is performed.

Said electric motor comprises a stator having a primary winding and a rotor having a field magnet, said field magnet comprising a first field magnet having different polarity magnetic poles sequentially arranged in a rotating direction and a second field magnet having different polarity magnetic poles sequentially arranged in a rotating direction, said first

and said second field magnets being opposite to magnetic poles of said stator; and a mechanism for changing a phase of a composite magnetic pole of said first and said second field magnets with respect to the magnetic pole of said first field magnet depending on a direction of torque, said mechanism for changing depending on a direction of torque comprising means for making magnetic pole centers of equal-polarity of said first and said second field magnets in phase by a direction of torque generated in said rotor and by balance of magnetic action forces between said first and said second field magnets; and means for making the magnetic pole centers of said first and said second field magnets out of phase when the direction of torque generated in the rotor is reversed.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram showing a washing machine having an embodiment of a permanent magnet type synchronous motor.

FIG. 2 is a schematic view showing a case (a first case) where magnetic pole centers of equal-polarity of the rotor of the motor in FIG. 1 are out of phase.

FIG. 3 is a schematic view showing a case where magnetic pole centers of equal-polarity of the rotor of the motor in FIG. 1 are in phase.

FIG. 4 is a schematic view showing a case (a second case) where magnetic pole centers of equal-polarity of the rotor of the motor in FIG. 1 are out of phase.

FIG. 5 is graphs showing various kinds of characteristics versus rotating speed of the motor in FIG. 1.

FIG. 6 is a control block diagram of the motor in FIG. 1.

FIG. 7 is a view showing another embodiment of a motor in accordance with the present invention (an actuator in OFF state).

FIG. 8 is a view showing another embodiment of a motor in accordance with the present invention (an actuator in ON state).

FIG. 9 is a view showing the inside of the rotor of another embodiment of a motor in accordance with the present invention.

FIG. 10 is a view showing the inside of a rotor of another embodiment of a motor in accordance with the present invention.

FIG. 11 is a view showing another embodiment of a motor in accordance with the present invention (an actuator in ON state).

FIG. 12 is a schematic view showing measurement of axial direction displacement in another embodiment of a motor in accordance with the present invention.

FIG. 13 is a schematic view showing a rotor of another

embodiment of a motor in accordance with the present invention (adding gap difference).

FIG. 14 is a view showing another embodiment of a motor in accordance with the present invention

FIG. 15 is a schematic view showing a rotor of another embodiment of a motor in accordance with the present invention (a case where the present invention is applied to a 8-pole motor).

FIG. 16 is a schematic view showing the arragement of another embodiment of a motor in accordance with the present invention.

【0008】

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiments of the present invention are explained hereinafter.

【0009】

FIG. 1 shows the outline of the washing machine in which the permanent magnet type synchronous motor according to this embodiment is provided.

【0010】

The permanent magnet field type synchronous motor which drives directly pulsator 73 is used as electric motor 2. Electric motor 2 rotates pulsator 73 and spin-drying drum 72 through the clutch.

【0011】

In washing machine case 70 shown in FIG. 1, there are outside tank 71 and washing spin-drying drum 72. This is a washing machine which comprises a washing spin-drying drum pivotted freely around rotation axis 22 in outside tank 71, pulsator 73 pivotted freely around a rotation axis whose center is the same as one of said rotation axis at the bottom of said washing spin-drying drum, change-over mechanism 77 for connecting or releasing the rotation axis of said washing spin-drying drum to the rotation axis of said pulsator, and electric motor 2, whereby washing or rinsing operation is carried out by rotating forward or reversely the body of revolution to stir the inside of said washing spin-drying drum, and then spin-drying operation is performed. There are two type washing machines. In one type, the water is collected only in the spin-drying drum, and in the other type, the water is accumulated in the whole water tank 71 including the spin-drying drum, when the rinsing is carried out. The present invention can be applied to the washing machine of which type.

【0012】

The washing machine of such configuration is driven by inverter 78. This inverter requires the control by a microcomputer, and is an electric motor control circuit with the function as the rotation control means for changing the number of revolution by receiving an instruction from the microcomputer.

The microcomputer control circuit is built into the inverter. Inverter 78 has the function as a motor electric current detection means by which the current value which flows to electric motor 2 is detected. Moreover, drain valve 74, system control panel 75, and water level sensor 76, etc. are further provided as the basic component element of the washing machine.

【0013】

FIG. 2 is a schematic view showing a case where the centers of equal-polarity of the rotor of the motor shown in FIG. 1 are out of phase.

【0014】

In FIG. 3, armature windings 11 are wound and set inside slots of a stator core 10, and bonded to a housing 13 having cooling paths 12 inside of which coolant flows.

【0015】

The rotor of a permanent magnet embedded type 20 is composed of a first rotor 20A fixed to a shaft 22 and a second rotor 20B separated from the shaft 22. Of course, the rotor may be a rotor of a surface magnet type instead of the rotor of a permanent magnet embedded type.

【0016】

In the first rotor 20A, permanent magnets 21A are arranged so as to be alternatively aligned magnetic poles of different polarity in the rotating direction. Similarly, in the first rotor

20B, permanent magnets 21B are arranged so as to be alternatively aligned magnetic poles of different polarity in the rotating direction. The field magnets coaxially arranged in the two rotors of the first and the second rotors are opposite to magnetic poles of the stator.

【0017】

A nut portion 23B is formed in the inner side of the second rotor 20B, and a bolt screw portion 20A to be in contact with the nut portion 23B is formed in the shaft. By connecting the second rotor 20B with the shaft with the screw function, the second rotor 20B is movable in the axial direction while being rotated with respect to the shaft.

【0018】

Further, a stopper 24 is arranged at a position apart from the side surface of the second rotor 20B so that the second rotor 20B may not exceed a preset displacement from the center of the stator. Furthermore, by providing a servomechanism of an actuator 25 for driving the stopper to make the stopper movable in the direction of shaft axis, the displacement between the magnetic pole centers of the first field magnet and the second field magnet can be varied. As the result, it is possible to control the total effective magnetic flux composed of the first field magnet and the second field magnet to the stator having the armature windings in the slits.

【0019】

Description will be made below on that the effective magnetic flux of the permanent magnets can be varied corresponding to the direction of torque by doing as described above.

【0020】

In an electric motor basically using armature windings in the stator and permanent magnets in the rotor, in the case that the rotating direction of the rotor is the same between when the motor is working as a motor and when working as a generator, the direction of the torque acting on the rotor becomes opposite. between when the motor is working as a motor and when working as a generator.

【0021】

On the other hand, in the case that the motor is working as a motor, the direction of the torque is reversed when the rotating direction of the rotor is reversed. Similarly, in the case that the motor is working as a generator, the direction of the torque is reversed when the rotating direction of the rotor is reversed.

【0022】

When the basic theory in regard to the rotating direction and the torque direction described above is applied to the embodiment of the motor in accordance with the present invention,

the following can be said.

【0023】

When the washing machine is driven in the low rotating speed region, for example, the washing or rinsing operation in which a big torque is needed, the high torque characteristic is obtained by compulsorily making the centers of equal-polarity of first rotor 20A and second rotor 20B arranged, and increasing the amount of the effective magnetic flux by the stator magnetic pole and the opposed permanent magnet as shown in FIG. 3.

【0024】

Next, when the electric motor is operated in a high rotating speed range, for example, spin-drying operation, the centers of equal-polarity of the first rotor 20A and the second rotor 20A are brought out of phase while the second rotor 20B is being moved with respect to the shaft 22 to widen the gap between the first rotor 20A and the second rotor 20A as if the nut portion were screwed off from the bolt screw portion, as shown in FIG. 4. Therefore, the effective magnetic flux by the stator magnetic poles and the opposite permanent magnets is decreased.. In other words, there is the weakening magnetic field effect, and a high output power characteristic can be obtained in the high rotating range.

【0025】

FIG. 4 schematically shows the state that the effective

magnetic flux by the stator magnetic poles and the opposite permanent magnets is decreased by making the centers of equal-polarity of the first rotor 20A and the second rotor 20A out of phase while the gap between the first rotor 20A and the second rotor 20B is being widened.

【0026】

In FIGs. 3 and 4, there are associative illustrations of a head portion 61 of a bolt, a bolt screw portion 60 and a nut portion 62. The head portion 61 of the bolt corresponds to the first rotor 20A, the nut portion 62 corresponds to the second rotor 20B. When the bolt screw portion 60 (corresponding to the part 23A in FIG. 2) is rotating a direction, the nut portion 62 is fastened or unfastened depending on the direction of torque acting on the nut portion 62. The similar phenomenon occurs in the second rotor 20B depending on the direction of torque acting on the rotor.

【0027】

On the other hand, in the case that the motor is working as an electric motor, the directions of the torque in the forward rotation and the backward rotation are opposite each other. Therefore, if FIG. 3 shows the state of the forward rotation, FIG. 4 shows the state of the backward rotation.

【0028】

A nut portion 23B is formed in the inner side of the second

rotor 20B, and a bolt screw portion 20A to be in contact with the nut portion 23B is formed in the shaft. Both of them are connected by using the screw function. Although the states shown in FIGs. 3 and 4 are opposite each other if the direction of the screw is reversed (for instance, from a left screw to a right screw), the same effect is obtained. Second rotor 20B is movable in the axial direction while being rotated with respect to the shaft.

【0029】

When the electric motor is operated in the washing or rinsing operation, high torque characteristic can be obtained by making the centers of equal-polarity magnetic poles of the first rotor 20A and the second rotor 20B are made in phase to increase the effective magnetic flux by the stator magnetic poles and the opposite permanent magnets, as shown in FIG. 3, even if it is in the forward rotation operation or the backward rotation operation.

【0030】

Next, when the electric motor is operated in a high rotating speed range, for example, spin-drying operation, the centers of equal-polarity of the first rotor 20A and the second rotor 20B are brought out of phase while the second rotor 20B is being moved with respect to the shaft 22 to widen the gap between the first rotor 20A and the second rotor 20B as if the nut portion

were screwed off from the bolt screw portion, as shown in FIG. 4. Therefore, the effective magnetic flux by the stator magnetic poles and the opposite permanent magnets is decreased. In other words, there is the weakening magnetic field effect, and a constant output power characteristic can be obtained in the high rotating range.

【0031】

Description will be made below on operation of the induced electromotive force by the electric motor in accordance with the present invention.

【0032】

FIG. 5 shows the characteristics of the effective flux, the induced electromotive force and the terminal voltage versus the angular rotating speed of the permanent magnet synchronous motor.

【0033】

The induced electromotive force E is determined by a constant magnetic flux Φ generated by the permanent magnets arranged in the rotor and an angular rotating speed ω of the electric motor. That is, as shown in FIG. 6 (a), if the constant magnetic flux $\Phi 1$ is constant, the induced electromotive force E1 is proportionally increased as the angular rotating speed ω (rotating speed) is increased. However, since there is a limitation in the output voltage of the inverter due to the

terminal voltage of the power supply and the capacity of the inverter, there is also a limitation in the induced electromotive force generated by the electric motor under a normal operating condition. Therefore, in the permanent magnet synchronous motor, it is necessary in a range above a rotating speed to perform what is called the field weakening control in order to reduce the magnetic flux generated by the permanent magnets.

【0034】

Since the induced electromotive force is increased in proportion to the angular rotating speed, the current of the field weakening control must be increased. Therefore, a large current needs to be conducted to the coil of primary conductor, and consequently the heat generated in the coil is increased, which may result reducing of the efficiency as a motor in a high rotating speed range and demagnetization of the permanent magnets due to heat generation exceeding the cooling capacity.

【0035】

For example, as shown in FIG. 5 (a), when the magnetic flux $\Phi 1$ generated by the permanent magnets arranged in the rotor is changed to the magnetic flux $\Phi 2$ at a point of the angular rotating speed $\omega 1$ (rotating speed), the induced electromotive force E1 of the motor is changed to the induced electromotive force E2. By this characteristic, the maximum value of the induced electromotive force can be limited.

【0036】

Similarly, FIG. 5 (b) is a schematic graph showing that when the magnetic flux Φ is changed little by little corresponding to the angular rotating speed ω (rotating speed), the induced electromotive force E can be maintained constant.

【0037】

In an embodiment of a means for obtaining the characteristics shown in FIG. 6, the first field magnet of a motor is fixed to a shaft, and the second field magnet is separated from the shaft. The shaft and the second field magnet have screw functions to be connected to each other by forming a bolt screw portion in the shaft and a nut portion inside the second field magnet. Further, a stopper is provided at a position apart from a side surface of the second field magnet, and a servo mechanism capable of moving the stopper in parallel to the shaft according to a rotating speed is provided.

【0038】

FIG. 6 shows the control block of electric motor 2 of FIG. 1.

【0039】

First of all, drive judgment part 101 judges the drive operation of permanent magnet type synchronous motor 2 based on the set information from system control panel (75 in FIG. 1), the information from water level sensor 76 and the number

of revolution of permanent magnet type synchronous motor 2, and outputs the electric current instruction value.

【0040】

The output from current control block 102 is converted into a three-phase alternating current in rotational coordinate transformation part 103, and controls permanent magnet type synchronous motor 2. Each phase current of permanent magnet type synchronous motor 2 is converted into the biaxial current by detecting each phase current (at least two phase currents) and the number of revolution, and fed back to the current instruction value. Further, the number of revolution, the magnetic pole position, etc. are detected by detector 106, and fed back to each control block through magnetic pole position transformation part 107 and speed transformation part 108.

【0041】

Although the embodiment of FIG. 7 comprises a position-and-speed sensor of the motor 2 and a current sensor of the motor, a control circuit of a sensor-less structure for driving the motor 2 without part of these sensors may be applicable.

【0042】

Further, since in the permanent magnet synchronous motor of the present invention, the pole centers of equal-polarity of the first and the second rotors are brought in phase or out

of phase corresponding to the operating condition, the permanent magnet synchronous motor of the present invention has a function of correcting a lead angle of current supply by a controller for controlling the inverter corresponding to a positional shift angle of the composite magnetic pole of the first field magnet and the second field magnet.

【0043】

An embodiment for correcting the lead angle of current supply will be described below.

【0044】

When the motor is operated by fixing the first field magnet to a shaft, by separating the second field magnet from the shaft, and by forming a bolt screw portion in the shaft and a nut portion inside the second field magnet to add screw functions to be connected to each other to the shaft and the second field magnet, the second filed magnet is moved in the axial direction while being rotated.

【0045】

FIG. 12 shows the relationship between rotation angle and displacement in the axial direction when the pole centers of equal-polarity of the first rotor and the second rotor are in phase or out of phase corresponding to the operating condition.

【0046】

Referring to FIG. 12, since there is a proportional

relationship between the rotation angle θ and the axial displacement ΔL of the second rotor, the axial displacement ΔL is measured using a displacement meter 64, and fed back to the position detecting circuit (the reference numeral 106 in FIG. 6) of the control circuit to be used for optimum control to correct the lead angle of current supply as a converted value of the shift angle of the composite magnetic pole position of the first field magnet and the second field magnet.

【0047】

FIG. 7 is a view showing another embodiment of a motor in accordance with the present invention.

【0048】

The first rotor 20A is fixed to the shaft 22, the second rotor 20B being separated from the shaft 22, the bolt screw portion 23A being formed in part of the shaft, a sleeve 41 being fixed to the inside of the second field magnet, the nut portion 23B being fixed to the inside of the sleeve 41. Thus, the second rotor 20B is rotated with respect to the first rotor 20A while the gap between the first rotor 20A and the second rotor 20B is being widened as if a nut portion were screwed off from a bolt screw portion.

【0049】

When change in flux linkage occurs between the inside of the second field magnet and the shaft 22 as the second rotor

is rotated because there is a small play between the second field magnet and the shaft 22, a trouble such as electrolytic corrosion may occur. Therefore, the sleeve 41 is made of a non-magnetic material having an electric resistivity higher than that of iron. By doing so, the inside of the second field magnet and the shaft 22 are magnetically and electrically insulated by the sleeve 41.

【0050】

Supporting mechanisms 40A, 40B are arranged inside the sleeve 41 so as to guide rotating motion, reciprocal motion and the composite motion between the second field magnet and the shaft.

【0051】

The second rotor 20B is connected to the shaft by forming a screw function of the bolt screw portion 23A in part of the shaft, and a movable stopper 24 is arranged at a position apart from a side surface of the second field magnet, and supporting mechanisms 42, 47 are arranged between the stopper 24 and the shaft, and between the stopper and the side surface of the second rotor 20B so as to guide rotating motion, reciprocal motion and the composite motion between the second rotor with respect to the shaft. The supporting mechanism 42 has a function of a thrust bearing, and the supporting mechanism 47 has a function of guiding the rotating motion, the reciprocal motion and the composite

motion though it is a radial bearing.

【0052】

Further, there is an effect that the function of the supporting mechanism 42 is improved as the thrust bearing by arranging a spring 48.

【0053】

Description will be made below on a magnetic clutch as an example of the servomechanism capable of moving the stopper 24 in parallel to the shaft.

【0054】

The structure of the magnetic clutch is that a coil 46 is wound around a yoke 44, and a stopper 24 may also serve as a movable core. The yoke 44 and the coil 46 are fixed to a frame 49 of the motor or to a part of the compressor, not shown, and a spring 45 is arranged between the yoke 44 and the stopper 24 so as to have a function of a reset device at braking excitation. A bearing 50 is arranged between the frame 49 and the shaft 22 to support the shaft 22.

【0055】

FIG. 7 shows the coil 46 under a non-excited state, and FIG. 8 shows the coil 46 under an excited state.

【0056】

The yoke 44 becomes a strong magnet by exciting the coil 46 to attract the stopper 24 also having the function as the

movable core.

【0057】

Next, when stopper 24 is attracted by exciting coil 46, the torque is applied while the second rotor 20B is being moved with respect to the shaft 22 to widen the gap between the first rotor 20A and the second rotor 20B as if the nut portion were screwed off from the bolt screw portion, as shown in FIG. 4. Therefore, the burden of the current flown to coil 46 is decreased.

【0058】

When the stopper 24 is attracted by exciting the coil 46, burden of conducting current to the coil 46 can be reduced by adding torque to the second rotor 20B so as to be rotated with respect to the first rotor 20A while the gap between the first rotor 20A and the second rotor 29B is being widened as if a nut portion were screwed off from a bolt screw portion.

【0059】

FIG. 9 shows an example of the sleeve 41 to be fixed to the inside of the second rotor 20B.

【0060】

As one of methods of fixing the second rotor and the shaft, the second rotor 20B and the sleeve 41 are fixed by forming projected and depressed portions on the contact surfaces of the two parts. Difference in the structure of the inside portions between the first rotor 20A fixed to the shaft 22 and the second

rotor 20B separated from the shaft 22 is shown in FIG. 9.

【0061】

FIG. 10 shows another embodiment of the present invention.

【0062】

A depressed portion 53 is formed on a side surface of the first field magnet where the first field magnet and the second field magnet are in contact with each other, and a projected portion 54 also serving as the function of the sleeve is formed in the second field magnet. The projected portion 54 and the sleeve 41 may be formed in a unit. By doing so, a sufficient space for the sleeve 41 can be secured. Therefore, this is one of methods of obtaining a motor having the second rotor of a thin axial thickness by effectively arranging the spring 48, the supporting mechanisms 40A, 40B and the nut portion 23B.

【0063】

FIG. 11 shows another embodiment of the present invention.

【0064】

The basic components shown in FIG. 11 are the same as those of FIG. 7, but a part corresponding to the magnetic clutch is changed. FIG. 11 shows the coil 46 under the excited condition, and the yoke 44 is detached from the stopper 24 by the spring 45 at cutting off the excitation. Further, the embodiment has a characteristic that a thrust force is applied to the second rotor 20B by the screw function due to an interaction between

the bolt screw portion 23A on which torque is applied and the nut portion 23B. Therefore, when the excitation of the coil 46 is cut off, the stopper 24 is detached from the yoke 44 by adding the thrust force to push out the stopper 24 due to the interaction between the screw and the torque. The yoke 44 is fixed to the frame 49 through an arm 52, or to a part of the compressor, not shown.

【0065】

Similarly to FIGs. 7 and 8, the magnetic clutch shown in FIG. 11 is an example of a servo mechanism capable of moving the stopper 24 in parallel to the shaft, positioning of the stopper can be more accurately performed by employing a hydraulic actuator, a linear driving device using a rotor and a ball screw, a linear motor or the like.

【0066】

FIG. 13 shows other embodiments of the present invention.

【0067】

The motor in accordance with the present invention is characterized by that the first rotor 20A is firmly fixed to the shaft 22, but the second rotor 20B has freedom to the shaft. Therefore, there is a small play in the mechanical dimension between the second rotor 20B and the shaft 22, and accordingly the second rotor 20B may become eccentric when large torque or a centrifugal force is applied to the second rotor 20B. The air

gap Gap 2 between the second rotor 20B having the second field magnet and the stator is made larger than the air gap Gap 1 between the first rotor 20A having the first field magnet and the stator. By doing so, the mechanical contact between the second rotor 20B and the stator caused by decentering can be prevented.

【0068】

A plurality of springs 48 and 51 are arranged between the stopper 24 and the second rotor 20B and between the first rotor 20A and the second rotor 20B, respectively. Thereby, there is an effect in that rapid fluctuation in the second rotor 20B can be suppressed, and motion of the second rotor 20B by the torque direction can be assisted.

【0069】

Of course, the component parts shown by the figures can be combined by various methods, or can be added or eliminated depending on the purpose of use.

【0070】

FIG. 14 shows the dynamo-electric machine according to another embodiment of the present invention.

【0071】

This is a permanent magnet type synchronous dynamo-electric machine in which screw 23 of the second rotor shown in FIG. 2 is eliminated, and the mechanism where the rotating angle θ can be moved is provided.

【0072】

The concavo-convex portion is provided to shaft 22 like the cogwheel instead of the screw part of the second rotor shown in FIG. 2, and the convexo-concave portion is provided to insert the shaft on the inner diameter side of the second rotor. However, only fixed rotating angle θ can be moved by enlarging the width of the ditch more than the width of the engaging teeth when shaft 22 is inserted into the inner diameter side of the second rotor. Further, a rapid collision can be softened by providing spring 26 and dumper 27 between the engaging teeth and ditches. Similarly, an actuator is provided. When the washing machine is driven in the low rotating speed region, for example, the washing or rinsing operation in which a big torque is needed, the high torque characteristic is obtained by compulsorily making the centers of equal-polarity of first rotor 20A and second rotor 20B arranged, and increasing the amount of the effective magnetic flux by the stator magnetic pole and the opposed permanent magnet as shown in FIG. 3.

【0073】

Next, when the electric motor is operated in a high rotating speed range, for example, spin-drying operation, the center of equal-polarity of the second rotor 20B is brought out of phase with respect to shaft 22, as shown in FIG. 14. Therefore, the effective magnetic flux by the stator magnetic poles and the

opposite permanent magnets is decreased. In other words, there is the weakening magnetic field effect, and a high output power characteristic can be obtained in the high rotating range.

【0074】

Although the above explanation of the present invention has been made on the four-pole motor, there is no need to say that the present invention can be applied to a two-pole motor or a six-pole motor. As an example, FIG. 15 is a schematic view showing a rotor of a permanent magnet synchronous motor in which the present invention is applied to an eight-pole motor. Further, the present invention can be applied to any type of rotor, an embedded magnet type or a surface magnet type.

【0075】

FIG. 16 is a schematic view showing washing machines of a direct drive method type and of a gear-combined method type.

【0076】

In FIG. 16, the component parts except the gear are provided in common. FIG. 16(a) shows the direct drive method, and FIG. 16(b) shows the gear-combined method. In FIG. 16 (b), gear 79 is provided on the shaft of said washing spin-drying drum and between change-over mechanism (77 of FIG. 1) for connecting or releasing to the shaft of said pulsator (73 of FIG. 1) and electric motor 2. The gear can be installed in change-over mechanism 77. Of course, it is needless to say that both are applicable as

an electric motor of the present invention.

【0077】

Since the permanent magnet synchronous motor in accordance with the present invention is constructed in that the rotors divided into the first field magnet and the second field magnet are arranged on the single shaft, and the pole centers of the first and the second field magnets are varied depending on the direction of torque, there is the effect that the effective magnetic flux by the permanent magnets opposite to the stator magnetic poles can be varied.

【0078】

Particularly, weakening magnetic filed control of the motor for the compressor of the air conditioner can be easily performed, and accordingly there is the effect of the wide range variable speed control.